Tools for Delta Smelt Management
Workshop Summary
US Fish & Wildlife Service in partnership with the Delta Science Program
February 17, 2010

Introduction: Cliff Dahm (Delta Science Program, Sacramento, CA)

Lead Scientist Cliff Dahm welcomed the participants and the public and gave a brief introduction to the workshop. The Delta Science Program hosted this workshop at the behest of the U.S. Fish and Wildlife Service (USFWS). The purpose of the workshop was to discuss the tools available for the management of delta smelt under the USFWS' biological opinion on OCAP. Calling attention to the posted agenda, he explained the general format for the presentations and noted that Delta Science would make the presentations and a written summary available on their web site. There would be a question-and-answer period following each presentation.

Opening Remarks: Dan Castleberry (Bay-Delta Fish and Wildlife Office, Sacramento, CA, U.S. Fish and Wildlife Service)

Dan Castleberry, field supervisor of the new Bay-Delta Fish and Wildlife Office, added his welcome to Dr. Dahm's and offered his thanks to all those involved with the workshop. Mr. Castleberry explained that the workshop was intended as an information-based / sharing session that was open to the public. It also served as a means for making the implementation of the USFWS' 2008 biological opinion (BO) as transparent as possible.

Background for Workshop: Victoria Poage (Bay-Delta Fish and Wildlife Office (BDFWO), Sacramento, CA, U.S. Fish and Wildlife Service)

As already mentioned, the workshop was intended to be informational. The purpose of the workshop was to explain and discuss the tools that were available for the management of delta smelt, specific to the biological opinion (BO). Keeping this in mind, the goal for the day was to provide a common understanding of the basic purpose, structure and intent of the BO, and of how it was implemented. The final product from the workshop will be a summary of the information presented.

Each of the presenters invited to participate in the workshop were asked to provide information in specific areas. These included the biological opinions themselves, as well as the various tools or processes with which they are involved, many of which are used by the Smelt Working Group (SWG).

Ms. Poage provided a brief overview of the BO. Delta smelt abundance, while highly variable, has been in decline for some time and during the last several years has been consistently very low. Delta smelt were listed as "threatened" under the federal Endangered Species Act (ESA) in 1993, and management actions since that time have been intended to address the threats identified in the final listing rule. These threats included habitat loss or modification, flow modification, entrainment into water diversions, water quality, invasive species, and predation. The BO describes three major ways in which water project operations affect delta smelt: (1) direct mortality from entrainment of pre-spawning adults, (2) direct mortality from entrainment of larvae and early juveniles, and (3) indirect mortality and reduced fitness from habitat modification. The biological opinion is intended to address these effects.

FWS BO Actions 1, 2 and 3: Victoria Poage (BDFWO, USFWS)

Ms. Poage introduced herself as the coordinator for the Smelt Working Group (SWG) and provided some basics about the Biological Opinion on the coordinated operations of the Central Valley Project (CVP) and the State Water Project (SWP), commonly known as "OCAP."

Current OCAP BO was issued to the U.S. Bureau of Reclamation (USBR) and California Department of Water Resources (DWR) 12/15/2008

The Bay-Delta Fish and Wildlife Office assumed responsibility for implementation in July of 2009

SWG organized in November 2009

A BO is a product of interagency consultation regarding ESA listed species and is the written opinion on the effects of the proposed project on the species in question. Formal consultation is a review process conducted between the USFWS and an agency or applicant. A consultation covers a discrete action. The consultation process determines the likely effects of a proposed action and identifies any alternatives.

"Incidental take" under the ESA is that which results from, but is not the purpose of, an otherwise lawful activity. This take cannot result in jeopardy to the species, and must be specifically authorized in the biological opinion. Take occurs at the state and federal water projects when listed species are entrained. The "incidental take statement" specifies the impact to the species, along with the amount or extent of allowable take. The authorization of take protects the agency or applicant from violation of the ESA. USFWS assumes that "salvage" is proportional to entrainment and therefore may be used as an indicator (index) of the number of delta smelt directly taken by the Projects. There is considerable uncertainty in this assumption, notably from screening efficiency and sampling error. The overall effect of take is depletion of numbers, although the population-level effect is unknown. Because the USFWS anticipates that the take of delta smelt will be minimized through the implementation of the "Reasonable and Prudent Alternative" (RPA), take is not likely to result in jeopardy to the species.

As mentioned in the previous presentation, water project operations have three major effects on delta smelt. The RPA is intended to address those effects. Importantly, it is the intention of the BO to avoid or minimize the direct effect of incidental take of delta smelt. Therefore, a proactive strategy is needed to protect delta smelt from entrainment. Indirect effects such as habitat constriction, entrainment of primary and secondary productivity, and decreased dilution of contaminants occur through degradation of habitat. Invasive species take advantage of changed hydrodynamic conditions. Flow velocity in Old and Middle Rivers (leading to the export facilities), termed “OMR flow,” is a key indicator of overall Delta hydrodynamics, and changes in OMR flow change a key underlying driver of future salvage of delta smelt.

The intent of the BO is to ensure that the CVP and SWP operations do not jeopardize delta smelt or adversely modify its critical habitat. The RPA has five “components” that address Project effects; this presentation will focus on only the first two. The objective of **Component 1, Actions 1 and 2,** is to reduce the entrainment of pre-spawning adult delta smelt during the December-through-March period by controlling reverse OMR flows. Action 1 is intended to protect adults migrating up into fresh water to spawn; Action 2 is intended to protect adults that have migrated upstream and are residing in the Delta prior to spawning. Component 1 increases the suitability of delta smelt spawning habitat by decreasing the amount of Delta habitat that is affected by the Projects’ export pumping operations prior to and during the spawning period.

Action 1 is further broken down into parts (a) and (b), to distinguish between early migration and later migration and movement within the Delta. The objective of Action 1 is to protect adult delta smelt from entrainment while the “first flush” of winter precipitation is flowing through the Delta. Turbidity is an indicator that the first flush is occurring. When the three-day average turbidity is greater than 12 NTU at all of three designated stations, Action 1 is triggered, and OMR flows are adjusted to no more negative than -2000 cfs for 14 days. Action 1 may also be triggered by salvage.

Action 2 is intended to tailor protection of adults to changing environmental conditions following Action 1. As in Action 1, the objective is to protect adult delta smelt from entrainment. Action 2 follows Action 1, but implementation is more flexible and based on an adaptive process. OMR flows may range from
-1250 cfs to -5000 cfs, depending upon the risk of entrainment.

The objective of **Component 2** is to protect larval and juvenile delta smelt from entrainment and afford them the opportunity to move out of the Delta and into their rearing areas in the low-salinity zone. Under **Action 3**, OMR flows are also managed adaptively and may range from -1250 cfs to -5000 cfs, depending upon the risk of entrainment.

The Smelt Working Group (SWG) reviews the physical, biological and technical (modeling) data and provides advice to the USFWS on the implementation of the RPA. The USFWS generally convenes the SWG in the fall, before December 1. The SWG uses the guidance in the BO, plus its best professional judgment, to provide advice to the USFWS, and the USFWS then makes the final determination as to whether or not an action should be implemented, and the level of protection required. The USFWS then provides a draft determination to the Water Operations Management Team, where it is discussed and finalized.

Victoria Poage: Questions & Answers

Q: Is a day-by-day accounting compiled for actions regarding the quantitative benefit (to delta smelt) of the action?

A: No attempt has been made to do this, but all SWG meeting notes and USFWS determinations are posted online.

Q: How does the Potential Entrainment Index (PEI) relate to the RPAs in the BO?

A: The PEI can potentially be used to assist in evaluating the risk of larval entrainment. DWR has provided it to the SWG in the past. Considering the present low abundance of delta smelt, use of the PEI may not be appropriate. Matt Nobriga and Jerry Johns will discuss the PEI in more detail later in the workshop.

Q: A lot of money has been used to improve the turbidity network in the Delta; how is that information being used by the SWG?

A: When the BO was written, the three stations that are used as criteria were selected partly because of their location and partly because they existed. Nothing precludes the examination of additional turbidity data. The SWG is generally provided with data from other, newer stations to consider alongside data from the criterion stations.

NMFS BO Action IV.2.3: Jeffrey Stuart (Sacramento Office, National Marine Fisheries Service)

Jeff Stuart introduced himself as the lead scientist for the development of the RPAs in the 2009 NMFS BO. He began with a cautionary statement that the RPA action described in this presentation is currently under a temporary restraining order (TRO) mandated by Federal Courts. Mr. Stuart indicated that the TRO was issued on Feb. 5, 2010 and would remain in effect until Feb. 19, 2010, unless it is extended for up to an additional 14 days.

The main focus of this RPA was to reduce the vulnerability of emigrating juvenile salmonids by addressing the hydraulic effects (i.e., reverse flows in Old and Middle Rivers (OMR)) of the state and federal water export projects.

In developing the RPA, NMFS looked at the salvage of emigrating juvenile winter run (WR) and spring run (SR) Chinook salmon and Central Valley steelhead (CVS) at the state and federal facilities. Salvage was reviewed with an eye to

both numbers and the times of year in which salvage events occurred. The main peak of juvenile WR emigration occurs from early March to mid-April, while the SR peak occurs from mid-March through early June, with a peak in April. The bulk of CVS emigration occurs from January through April, with a tail extending through June.
A particle tracking model (PTM) was used to assess the fate of particles due to Delta hydrodynamics. Particle entrainment was found to be a function of proximity to the exports facilities and export magnitude. The PTM was used to develop a generalized entrainment footprint for the Projects at varying OMR flows. The relationship between OMR flows and observed entrainment appears to be very good for winter run, which have essentially one route for entering the central and southern Delta interior– the Georgiana Slough/Mokelumne River route. The relationship is good for Central Valley steelhead, but exhibits more scatter due to multiple entry points into the central and southern Delta arising from populations in both the Sacramento and San Joaquin River basins.
Implementation of the RPA is based upon the pre-existing Salmon Decision Tree. Several indicator metrics are used, including:

Winter Run loss density indexed to the juvenile production estimate (JPE) for winter run

Loss density of older juvenile Chinook salmon

Percent loss of tagged hatchery fish: late-fall run Chinook salmon used as surrogates for yearling spring run, and tagged hatchery winter-run for the winter-run produced by the Livingstone Hatchery

The implementation points/triggers are not currently being used due to the TRO (mentioned earlier). However, the RPA action provides criteria by which recommendations for staged export reductions may be made when salvage criteria are met or exceeded. When triggered, export reductions are implemented for five consecutive days. If salvage levels fall below the implementation trigger during the last three days of the initial 5-day export reduction period, exports may return to the base level after day 5. If, however, salvage levels still exceed the triggering criterion used for the export reduction, the exports will remain at their reduced level until salvage falls below the triggering criterion for 3 consecutive days. If salvage continues to increase, an additional reduction in the export levels may occur if the higher trigger standards are exceeded.
The BO creates the Delta Operations for Salmonids and Sturgeon (DOSS) team to advise NMFS on modifications to Project operations. The DOSS team meets biweekly, except during the periods when salvage of listed salmonids is expected to occur, during which time it meets weekly.

Jeffrey Stuart: Q&A

Q: Why not implement the use of physical barriers to separate the fish from the water?

A: Such physical barriers are typically cost prohibitive and not really implementable in most situations due to engineering limitations and other associated variables. Large physical barriers may costs tens of millions of dollars.

Q: What does the term “loss” actually mean, in relation to salvage?

A: Loss is an estimate of the number of fish actually lost to the system due to the direct effects of the export actions. It is essentially the difference between the total number of fish entrained by the export facilities and the number of fish salvaged and returned to the system. Loss accounts for the predation of fish immediately prior to encountering the fish screens, the efficiency of the fish screen louvers, and the loss associated with collection, handling, trucking and release of the fish back into the Delta system. Loss is higher at the SWP than at the CVP, due to high predation in Clifton Court Forebay.

Q: Why does it sometimes take weeks for fish to move from Knights Landing to Chipps Island or to the pumps?

A: Fish entering the Delta from upstream locations may spend some time (days to weeks) rearing in the Delta, but when they begin to move through the system towards the ocean, they become vulnerable to entrainment.

Q: Is PTM a suitable model for salmonids?

A: PTM is not intended to depict actual fish “movement,” only to estimate a “risk” of the potential for the fish to end up in a certain place. Although it is the best tool currently available, studies have been proposed to improve the model.

Q: Is salvage or loss the more important factor?

A: Salvage and direct loss by themselves are an inadequate metric, as they do not include the impact of the indirect loss associated with the export actions. When salvage is combined with both direct and indirect loss, it estimates the total number of fish that are exposed to the effects of exports. Methods for estimating indirect loss are still being refined.

Q: Has NMFS considered separating the fish from the water?

A: NMFS has considered both non-physical barrier and physical barrier technology. A physical barrier that would meet the appropriate criteria for screening efficacy would likely be too costly to construct. The RPA provides a process for NMFS to consider different technologies to achieve the separation of fish from the water being conveyed towards the export facilities.

Q: Would you please explain what is going on with the acoustic tagging studies? What is the expectation?

A: This six-year study beginning in 2011 is intended to contribute to an improved understanding of fish behavior at channel splits and transitions to areas of tidal dominance. The study will also look at reach mortality, transit time, and predation “hot spots” (such as Head of Old River near Mossdale) and at other temporally and spatially recurring events. The information could be used to adaptively manage flows to reduce the effects of Project operations.

Smelt Working Group Tool Box: Matt Nobriga, California Department of Fish and Game, Sacramento, CA

Matt Nobriga is a member of the Smelt Working Group.

This presentation describes “The science and the art of the Smelt Working Group.” The SWG uses strong science but also uses some “art” in the interpretation of the science. Smelt are often associated with turbid water and are susceptible to negative OMR flows when the water in the central and south Delta is turbid. The main tasks of the SWG are to prevent major entrainment events and manage first flush events.

The biological opinion uses the FMWT index to set the incidental take limits for each year. The SWG acts as an entrainment management advisory group. Entrainment almost always happens when OMR flows are negative.

Data from the Spring Kodiak Trawl (SKT) survey, which begins in January each year, is also reviewed by the SWG. The present apparent low abundance of delta smelt is related to detectability and sampling efficiency. Detectability is a function of the ability of the species to aggregate; delta smelt have much less ability to aggregate in the south Delta. The SKT (a gear that trawls at the water surface) is not particularly efficient for longfin smelt, which are thought to be less surface-oriented. The SKT is conducted monthly, which is a relatively long interval for a motile species while it is migrating upstream. Assumptions made concerning distribution become increasingly inaccurate over time.

Salvage of smelt almost always occurs with the net flow in the south and central Delta going toward the export pumps – negative flow. We have learned something about run times and cues; longfin smelt cue on water temperature but delta smelt cue on the first flush and its attendant increased turbidity. Relative spawning location is important. Our ability to draw inferences from salvage is limited by pre-screen losses and louver efficiencies.

The observed distribution of smelt in a survey is a function of their abundance and ability to aggregate into detectable groups. It may be that the reason we now “find” more of them in the northern Delta is because it is more turbid and because they are better able to aggregate there. Trends described by particle tracking modeling (PTM) are now fairly well known. Particles that move up in the water column during the flood tide and down in the water column on the ebb tide can move to the SWP pumps within 30 days of release at Chipps Island – even against substantial net downstream flows.

There are key differences between larval longfin and delta smelt. Hatch time, dispersal, location relative to X_2 and salvage peaks all differ. Delta smelt travel further inland to spawn while longfin smelt tend to stay further seaward. The delta smelt also stay 5-20 km from X_2 as larvae, whereas longfin larvae tend to center at X_2. The salvage peak for longfin smelt occurs in April, while the delta smelt peak occurs in May and June.

The SWG uses a fixed station approach as the current best available science to protect larval delta smelt from entrainment. The intent of this approach is to protect the lower San Joaquin River from too much draw into Old and Middle Rivers, because once larvae enter the south Delta they are not likely to avoid entrainment. The SWG uses the DSM2 PTM, a one-dimensional model, without behavior. This appears to work well because the concept – entrainment – is simply a function of flow.

An alternative to the fixed station approach is the use of the Potential Entrainment Index (PEI). Numerous concerns limit the use of the PEI as a tool for SWG, including:

- Doesn't accurately represent the distribution of larvae smaller than 12-mm
- Doesn't consider hatching times / locations
- Doesn't factor in hydraulic residence times
- Doesn't look at the different behaviors between different smelt
- Its quantitative reliance on hydrologic forecasts introduces uncertainty
- It accounts only for CVP/SWP entrainment – not indirect mortality
- No propagation of statistical uncertainty

The PEI is based upon distributions assumed from the 20-mm Survey, which is limited by inefficiency in collection of the smallest fish and increasingly limited by ever lower numbers of larvae. Because the effect of exports greatly depends on the location of the fish in relation to the pumps, and we don't know when or where these fish will hatch, it is risky to manage based on an automated process. Essentially all particles that flux into Old and Middle Rivers in DSM-2 either end up in an agricultural diversion or at the pumps.

Matt Nobriga: Q & A

Q: Is the simple model that just looked at up and down movement of the fish in the vertical water column based on actual fish behavior?

A: This is one of many behaviors documented for other small pelagic fish in other estuaries. They are unlikely to use it as "routinely" as the model portrays.

Q: Are delta smelt susceptible to agricultural diversions?

A: Not to the same extent as to exports, but there are a lot of agricultural diversions in the Delta.

Q: Would screening help?

A: Not in Old and Middle Rivers because the fish would still eventually be entrained at the SWP or CVP.

Q: What happens to delta smelt that aren't salvaged?

A: Some die in the Delta, but conditions should support others moving out of the Delta.

Q: Re: the PTM that showed all the particles from Chipps Island going to the pumps, what is the relevance of this modeled outcome given that we know that not all delta smelt at Chipps Island end up at the pumps?

A: The outcome shows the result of “tidal surfing” behavior; there are other behavioral cues in addition to the tidal cycle. The model run was intended to show how much movement can occur in 30 days.

Q: Would the SWG be willing to do the accounting to show whether their recommendations actually reduced salvage at the pumps?

A: The SWG is not tasked with tracking population dynamics, only with making recommendations on Project operations. We have not attempted to come up with numbers.

Q: Please compare the “art” versus the PEI type of approach.

A: The PEI could be a potentially useful tool, but it is not sophisticated enough to be used as a decision tool for the SWG – there is just too much noise in it to filter out.

Q: How does the SWG feel about the RMA model?

A: This is a tool with a lot of potential. It makes good use of the data that we already have, but needs more development. We could use it in the future, but it isn’t ready yet.

Q: The relationship between OMR flows and entrainment risk at station 812 is well-described; do we need to keep using the PTM or can we use it to develop a simple, empirical model?

A: Definitely – there is little need for additional PTM runs.

Q for Ms. Poage: In setting up the framework of the BO the use of OMR flows were used. Does the SWG determine OMR flow based on entrainment? How does the SWG respond to salvage data?

A: The RPA provides guidance for setting OMR flows when a large portion of the delta smelt population appears to be in the central Delta. OMR flows would be set to reduce the risk of entrainment.

Entrainment Investigations: Gonzalo Castillo, Stockton Fish and Wildlife Office, U.S. Fish and Wildlife Service

This investigation addressed two unaccounted sources of entrainment losses of delta smelt at the State Water Project (whole-fish-facility losses and pre-screen losses). Other unaccounted potential entrainment sources include near- and far-field losses and capture/handling/trucking/release (CHTR) losses which were not evaluated as part of this pilot study funded by the Delta (former CALFED) Science Program. The main goal was to obtain preliminary estimates on pre-screen and fish facility losses of adults and juveniles. The objectives were to: 1) develop and evaluate the efficacy of mark-recapture methods to conduct mass mark-recapture studies on delta smelt, 2) evaluate the extent of losses within the Skinner Fish Facility (SFF) and, 3) obtain preliminary estimates of the pre-screen losses of fish entrained into Clifton Court Forebay (CCF). The specific questions asked in this study were:

• Can delta smelt be mass-marked to achieve high post-marking survival and retention of the mark?
• What is the initial estimate of entrainment losses within the SWP? Including:
  - Fish facility efficiency at SFF
  - Percent recovery of fish entrained into the CCF
  - Pre-screen losses in CCF

The delta smelt used for this study were obtained from the U.C. Davis Fish Conservation and Culture Lab. The tested marking methods were: (1) calcein immersion (adults and juveniles), (2) photonic marking (adults), and (3) trans-generational strontium marking (adults).
During the first year of SWP operations no pre-screen losses occurred in CCF; the SFF salvaged fish directly entrained from the Italian Slough. Fish entrainment into CCF became a permanent feature of SWP operations in subsequent years. A key objective of this study is to investigate the potential role of CCF in terms of direct entrainment losses of juvenile and adult delta smelt in the SWP.
Assumptions that were tested and validated included: (1) marked fish will be recognized and reported, (2) the mark will be retained, and (3) there would be no difference in mortality between marked and unmarked fish. Initial conclusions are: 1) delta smelt can be effectively mass-marked, 2) pre-screen losses of delta smelt may at times be much higher than for other previously studied species in CCF, and 3) the reported salvage for delta smelt may not provide a consistent index for underlying entrainment patterns, as inferred from the February, March and June mark-recapture experiments conducted in 2009.
Substantial further work could be done using the marking protocols developed as part of this pilot study, including, seasonal entrainment monitoring and studying the effect of release location and estimating entrainment losses of larval delta smelt at the SWP and CVP. Additional work could also take advantage of new technologies as they become available, such as smaller passive integrated transponder (PIT) tags and radio tags.
Gonzalo Castillo: Q&A

Q: Could this work be adapted to “reducing” entrainment, if an alternate (two-mile salvage corridor from Italian Slough) approach were built? Would this have the effect of reducing transit time?

A: A better venue for this discussion would be the Fish Facilities Forum.

Q: What about water temperature in the CCF, especially when high in months like June? Was that taken into account in the survival calculations? How long did laboratory fish survive at equivalent temperatures?

A: Temperature was taken into account and did not seem to be an issue for analysis of this experiment. Survival in the control group was good - about 90 percent over several days. The control group experienced high mortality after the experiment concluded. Temperatures during the release were not an issue. It would be possible to repeat the experiment during VAMP, when water residence times in CCF are higher.

RMA's Smelt Behavior Model: John DeGeorge, Resource Management Associates
This model is based upon the hypothesis that the distribution of delta smelt in the upper estuary is related to water turbidity. If fish can sense concentrations and then "surf" to get to the concentration that they appear to prefer, then can their movements be modeled?
The model makes the following assumptions:

Adult delta smelt salvage is related to turbidity distribution

Turbidity and electrical conductivity (EC) are primary drivers in where the adults are positioned

Delta smelt begin to move up the estuary in late fall to early winter. Just using an upstream flow to model their movements doesn't work; if it did, then many more delta smelt would simply end up at the export pumps. A behavior set was created so that the model fish would move away from high salinity and low turbidity (defined as 16 nephelometric turbidity unites (NTU)), with an added element of stochasticity. To accomplish this, the model uses the following behaviors:

Movements occur by "surfing" the tidal flow

The fish move away from high EC (this is their desire to move upstream to the freshwater gradient)

The fish move away from low turbidity (seek higher than 16NTU)

Still, these behaviors don't tell the model fish when to "stop," so an algorithm was added for the fish to randomly explore a given region of acceptable habitat when found.
Turbidity simulations were originally developed in 2007-2008. To better fit observed patterns, an exponential decay component was added. However, the model does not presently predict spikes in turbidity that result from resuspension due to windy conditions. Future work will involve the development of a wind resuspension component. Particle behavior can occur as a function of a variety of factors; this model uses salinity and turbidity, but more variables are available and could be tried.
The model may be used to derive a normalized weekly salvage. At present, it's hard to say whether or not the pattern is right. Performing a sensitivity analysis is difficult; a Fourier analysis could be a better approach. Dr. Bryan Manly has been working with RMA to develop a bootstrap analysis to generate confidence intervals about the predicted entrainment as a function of uncertainty in the turbidity model.

The present “state of the model” is that it is producing reasonable patterns of entrainment, although more work is needed on in-Delta fish distribution. The model is currently a “top-down” approach to the system, but other approaches could be explored. Turbidity is a critical driver, making incorporation of the best new data imperative. The slack-water sampling (Jon Burau and Bill Bennett) results should be helpful in fine-tuning the model.

Work is presently in progress to develop a real-time component; a weekly capability should soon be available. This component will be able to interpolate the data from the new turbidity stations. They are also working on a forecasting function; the first trial forecast will be conducted February 7-28th to evaluate the performance of the model.

John DeGeorge: Q&A

Comment: Given Dr. Castillo’s observation that salvage efficiency declines as the season progresses, you may be able to produce better results if salvage efficiency is adjusted to decline through the season.

A: Definitely something to consider.

Q: Can you actually apply a Fourier process to export pumping?

A: We’re not entirely sure, but it can be used to test salvage patterns against one another. We are looking for a goodness-of-fit discrimination.

Q: Does the model account for adults seeking higher turbidity, i.e., that higher turbidity is always better?

A: Yes. The model uses a threshold, along a frequency distribution, of 16 NTU. Above 50 NTU there are no data.

Q: Re: exponential decay of turbidity, are you seeing improvements using the additional station data?

A: We are getting a much better understanding of the turbidity transport in the system with the new data collected this year. We are still encountering issues with missing boundary conditions (un-gauged inflows). A full-blown sediment model requires more data than we presently have available.

Q: The turbidity model is great, but does the fish behavior component really work?

A: We have shown reasonable correspondence with salvage patterns, but it is very difficult to precisely quantify fish distributions and entrainment. There is still important work to be done to develop an effective method of quantitatively comparing predicted and observed fish distributions to discriminate between behavior hypotheses.

Potential Entrainment Index (PEI) for Delta Smelt: Jerry Johns, California Department of Water Resources, Sacramento, CA

The Potential Entrainment Index (PEI) is a tool, not an answer, and as such is a work in progress. The model is applicable to young juvenile delta smelt. It is one way to look at the full distribution of juvenile delta smelt and estimate the overall risk of entrainment to the proportion of the population at this life stage.

The range of OMR flows identified in the USFWS biological opinion (-1250 cfs to -5000 cfs) for both adult and larval/juvenile smelt protection can be problematic for the State Water Project in terms of water supply costs. During the January to June timeframe this range can vary greatly and result in a discretionary scale of 1.3MAF.

Thus far it has proven difficult to link entrainment to overall abundance. The link between OMR flows and salvage is less clear for juveniles than for adult delta smelt. As a result of implementation of the biological opinions, spring OMR flows may be limited at times to no more negative than -2000 cfs. Use of the PEI may provide an additional tool for determining the entrainment risk for young juvenile delta smelt on a near real-time basis so that OMR flow criteria may be more flexible during this time of the year.

The PEI can be derived using results of the DSM2-based Particle Tracking Model (PTM) or from regression equations (PEI Calculator). From the PTM, PEI is calculated using percent entrained particles from 20-mm survey stations, the relative abundance of delta smelt at these stations and water volume for the stations. The PEI Calculator utilizes regression models developed for relationships between hydrodynamic conditions (OMR and Qwest) and particle entrainment for individual 20-mm stations. Values for each station are summed to calculate the PEI.

The PTM-based PEI can take several days to run, but the PEI Calculator version may be run for quick reference. DWR runs both models every 2 weeks to inform decision making. Presently, the model looks at biweekly effects, but applications under development have also looked at seasonal and annual impacts.

The DSM2-PTM depicts particle movement without factoring in fish behavior. Hydrologic variability alone is difficult to predict – now we are also trying to predict entrainment to facilitate improved management of export operations.

Applications of the PEI include focusing on minimizing peak entrainment events, estimating the outcome of setting a biweekly entrainment limit (e.g., 5 percent), seasonal or annual entrainment limit (e.g., 10 percent), comparing historical PEI, target PEI (e.g. 5 percent) and associated water supply impacts and potential for estimating annual juvenile salvage.

It is, however, appropriate to limit “peak” entrainment.

Several concerns (C) are apparent regarding use of the PEI; potential resolutions (R) are also offered:

1. C: Using only the PEI method to determine OMR flows is not appropriate.

R: Continue current practice of utilizing all available information, data and expertise in decision making process as outlined in the BO; PEI could be one of several key tools.

2. C: Fish abundance is so low as to affect the reliability of survey data (required input to the model).

R: 20-mm Survey data is still the best available data. More extensive sampling at each station, more sampling during April-June; more effective gear could address this issue.

3. C: Incomplete data sets affect the distribution data for the model.

R: Again, this is the best available data and has always been used for management decisions regardless of missing information. By applying necessary assumptions, these data can be used with the PEI methodology.

4. C: Does not incorporate salvage as an indicator that delta smelt are present in the south Delta.

R: Can be added; the catch-per-unit-effort (CPUE) would be different, and much more effort would be incorporated; 4,000 cfs of export pumping generates 1,000 times more effort than a 20 mm survey station. Could consider salvage as a single data point.

5. C: Larval fish are not counted in routine salvage operations; how can they be accounted for in the PEI?

R: Utilizing information on adult fish from the Spring Kodiak Trawl, larval fish distribution can be assumed to be similar to adults.

6. C: 20-mm Survey does not generate data in real-time.

R: None of the survey data are available in real-time. Data become available within 72 hrs; partial data sets can be used for initial estimates of OMR.

7. C: PEI annual salvage target levels are too high.

R: Use current BO process for setting and implementing OMR flow criteria. Set reasonable near-term and annual targets.

8. C: Particle tracking simulations should exceed 20 days.

R: Particle tracking simulations typically determine ultimate fate of particles and utilize “initial” injection and tracking over 30 to 45 days. DSM2-PTM PEI method utilizes 20-mm Survey data that resets injection points every 14 days.

9. C: Behavior simulation, recruitment and mortality estimates are not included in the DSM2-PTM.

R: These can be added to DSM2-PTM or different models can be used to generate PEI-type values.

Jerry Johns: Q&A

. Q: Re: including salvage in the PEI model, does this require funding more work at CCF? Would it consider the pre-screen loss described in Dr. Castillo's research?

A: Yes, consideration should be given to pre-screen losses; work is in progress on developing a salvage CPUE, but more work at CCF may be required, as well as additional funding.

Q: Re: larval delta smelt and turbidity, conditions in the Delta are at or near the threshold for successful feeding; does this need to be factored in? This increase in water clarity may be the main root cause of the smelt decline.

A: Possibly; it is fairly clear that there are fewer fish in the south Delta now versus the historic condition.

Q: Does the PEI conform to an export-to-inflow (E/I) relationship? Does the PEI include a factor for entrainment versus distance?

A: The model does different things contingent upon the given station it is looking at. So, yes, in some regard (on some of the stations) it does take distance into account.

Open Discussion / Questions

. For Dr. Castillo: What were the protocols regarding the release of the fish; what was the location, when was the release and what was the flow?

A: The gates were typically open during release, and the releases occurred at 2 p.m. The fish dove upon release – there is a gyre in the Forebay that stirs the fish around, so they should have circulated as expected. The winds did not seem to have much influence /effect. The release point was approximately 30-50 feet from the radial gates, which has been a common location for similar releases. Some release points can't be used because of safety issues or bird predation. The level of the Forebay or removal of vegetation could be considered in future work.

For Dr. Castillo: What are your thoughts on any differences that may exist between wild and laboratory fish in such an experiment?

A: Stress levels would probably be higher in wild fish. Because the cultured fish are accustomed to captivity they may be less likely to be traumatized, and could experience better survival.

For Mr. Nobriga: In your presentation you listed about a half-dozen issues that you saw with the PEI model as a tool – did you hear anything in Jerry Johns' presentation on the PEI model that would cause you to shorten your list?

A: No. It didn't add anything to my list, either.

From Mr. Johns: It would be nice to take a more collaborative approach to further refining the PEI.

For Mr. Johns: Could spawning areas be back-calculated from the 20-mm Survey data and incorporated into the PEI?

A: This is something that DWR wants to do, as it seems as though it could be helpful.

. Comment from Ted Sommer to all the modelers present: The “gold standard” is publication. It’s much easier for the scientific community to consider using these models if they have undergone critical evaluation by the scientific publication process. It’s difficult to cite your work without peer review.

. Reply from the modelers: They would like to do this, but get paid to create models, not to publish them. They noted that the models discussed today have been vetted through the modeling community, if not through the science community.

Lively discussion on the relative merits of peer review followed these comments. Dr. Dahm noted that peer review is still the “standard” and is the best forum available.

For Dr. Castillo: Will you be able to incorporate residence time into your results?

A: Yes, that is part of the study plan; the analysis has already begun. Results will be reported as averaged over a 24-hour period; in each case, it took a week to complete the recoveries. This study was part of a larger Interagency Ecological Program/Pelagic Organism Decline (IEP/POD) study that collected a lot of simultaneous data.

Comment: There are many ways for fish to die in CCF – entrainment is only one. Why not rear threadfin shad in a hatchery to feed the predators so that they would not eat the listed species? Pumping hard saves fish; trying to save fish by pumping less backfires.

Q: Is turbidity in the south Delta so low that delta smelt would have trouble feeding?

Response from Joan Lindberg: In the lab, delta smelt feed better at 20 NTU than at 10 NTU. The curve flattens out at about 15 NTU, and there is a very big drop in feeding at 5 NTU. None of the fish survive at 0 NTU. Once the larvae are 30-40 days old turbidity is less an issue for feeding than simply for cover.